



# Waste management and Sustainability Transition - Outlooks in Japan

**Keishiro Hara, Ph.D.**

Osaka University, Sustainability Design Center  
(hara@sdc.osaka-u.ac.jp)

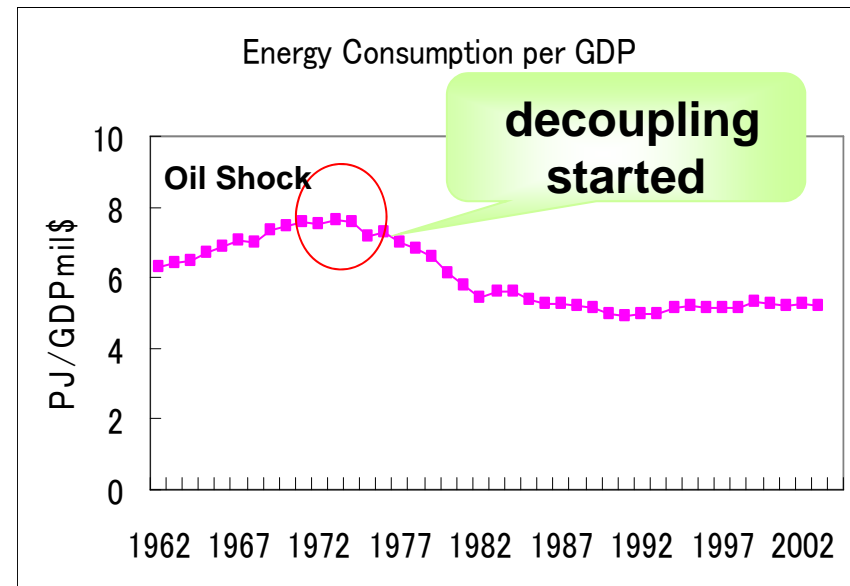
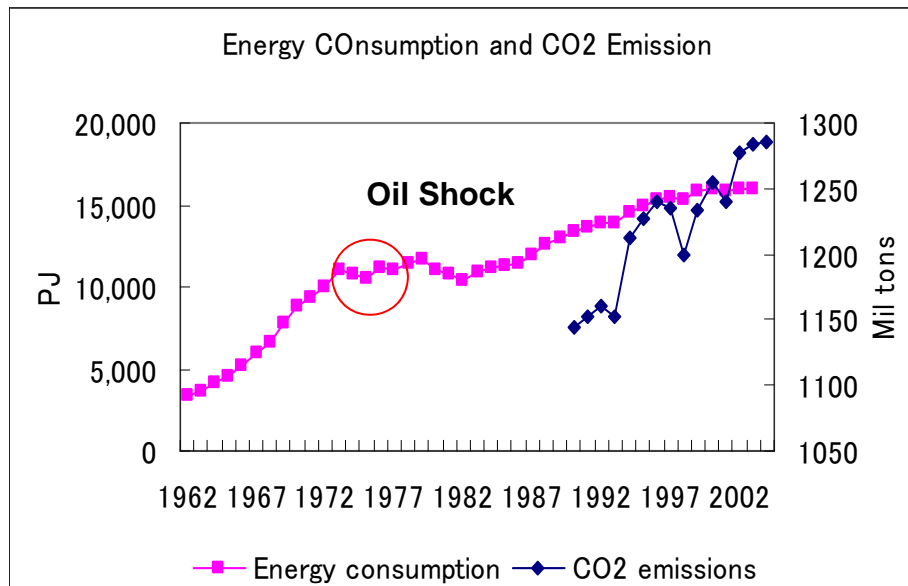
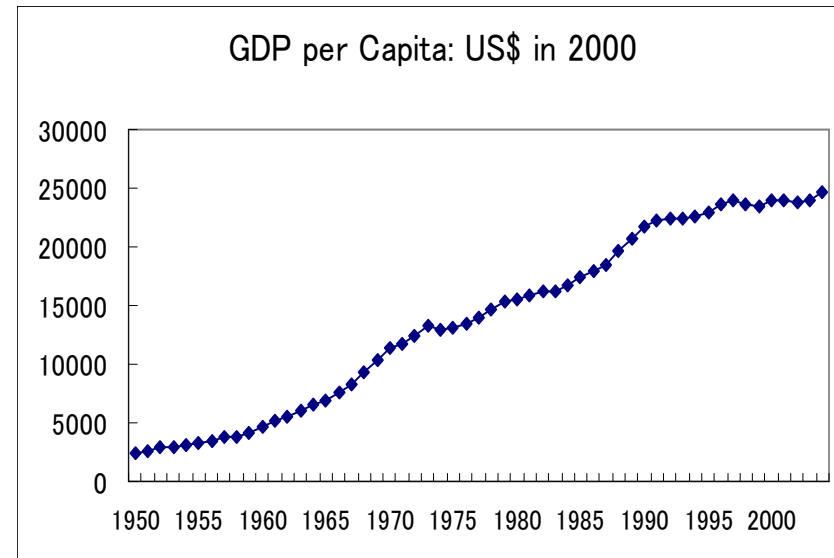
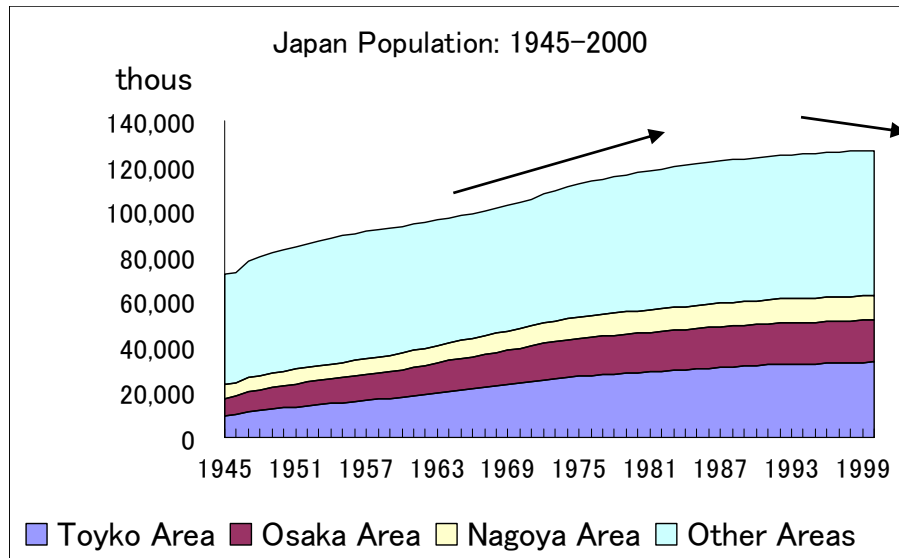
July 12, 2010

*Special Seminar, University of Tsukuba*

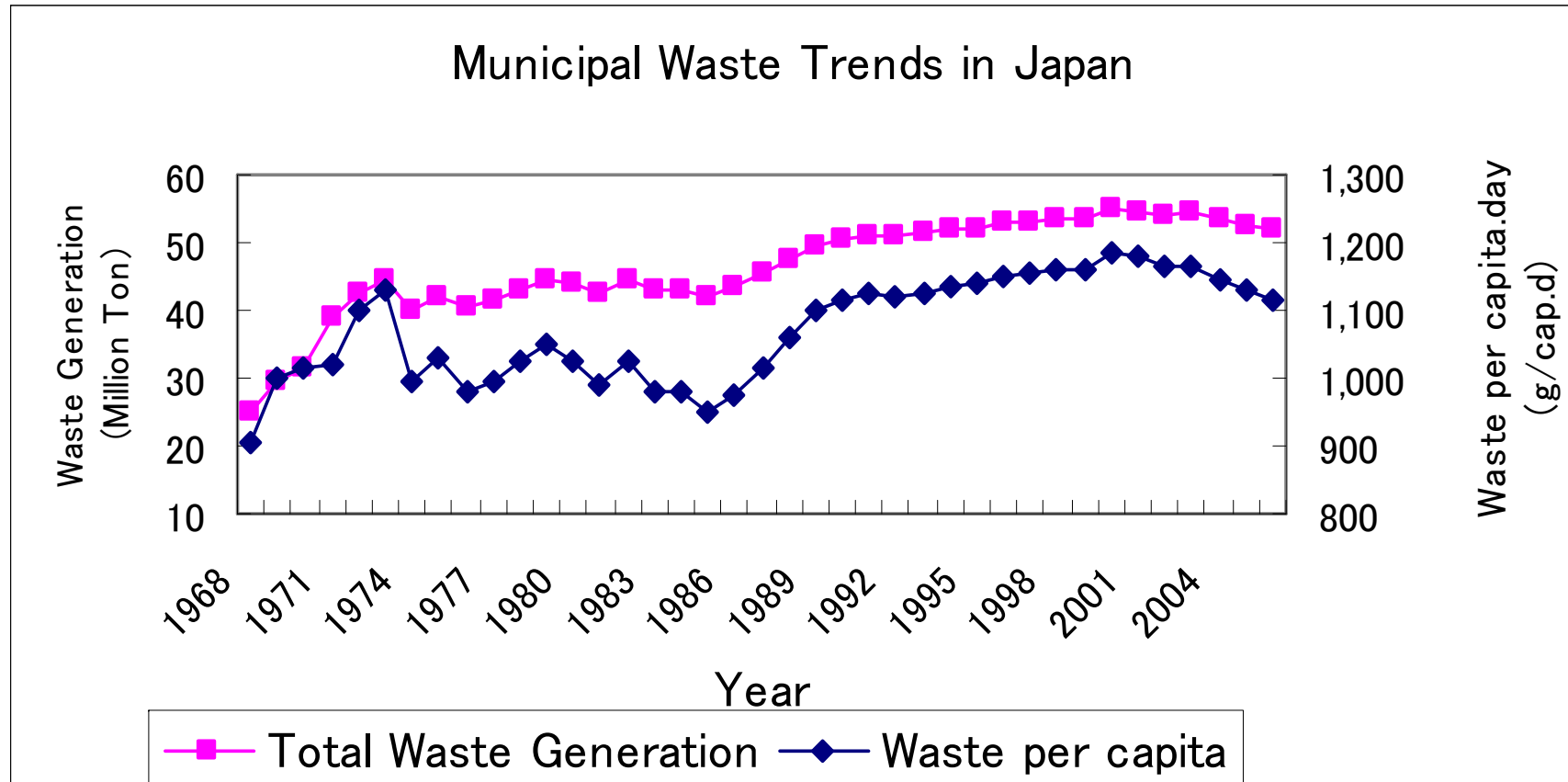
# Today's lecture

1. A brief overview of evolution of waste management and promotion of Sound Material-cycle society in Japan
2. Biomass wastes utilization towards a new perspective for waste management and low carbon society – a case of sewage sludge

# Socio-economic conditions in Japan



# Chronological Trend of Municipal Waste Generation In Japan



Data Source: Ministry of Environment, Japan

# Economic Status and Waste Generation in Asian Nations and Japan

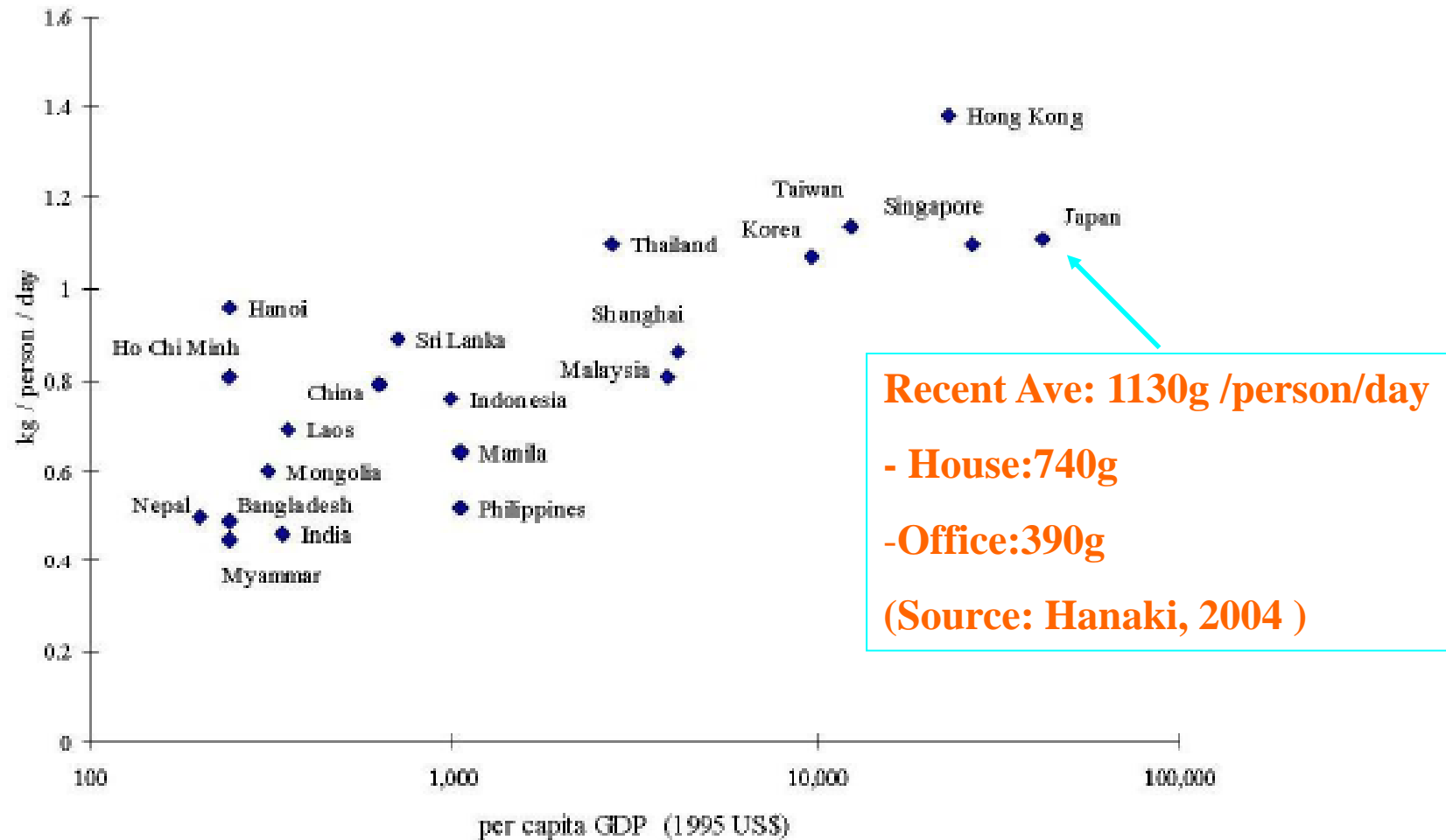
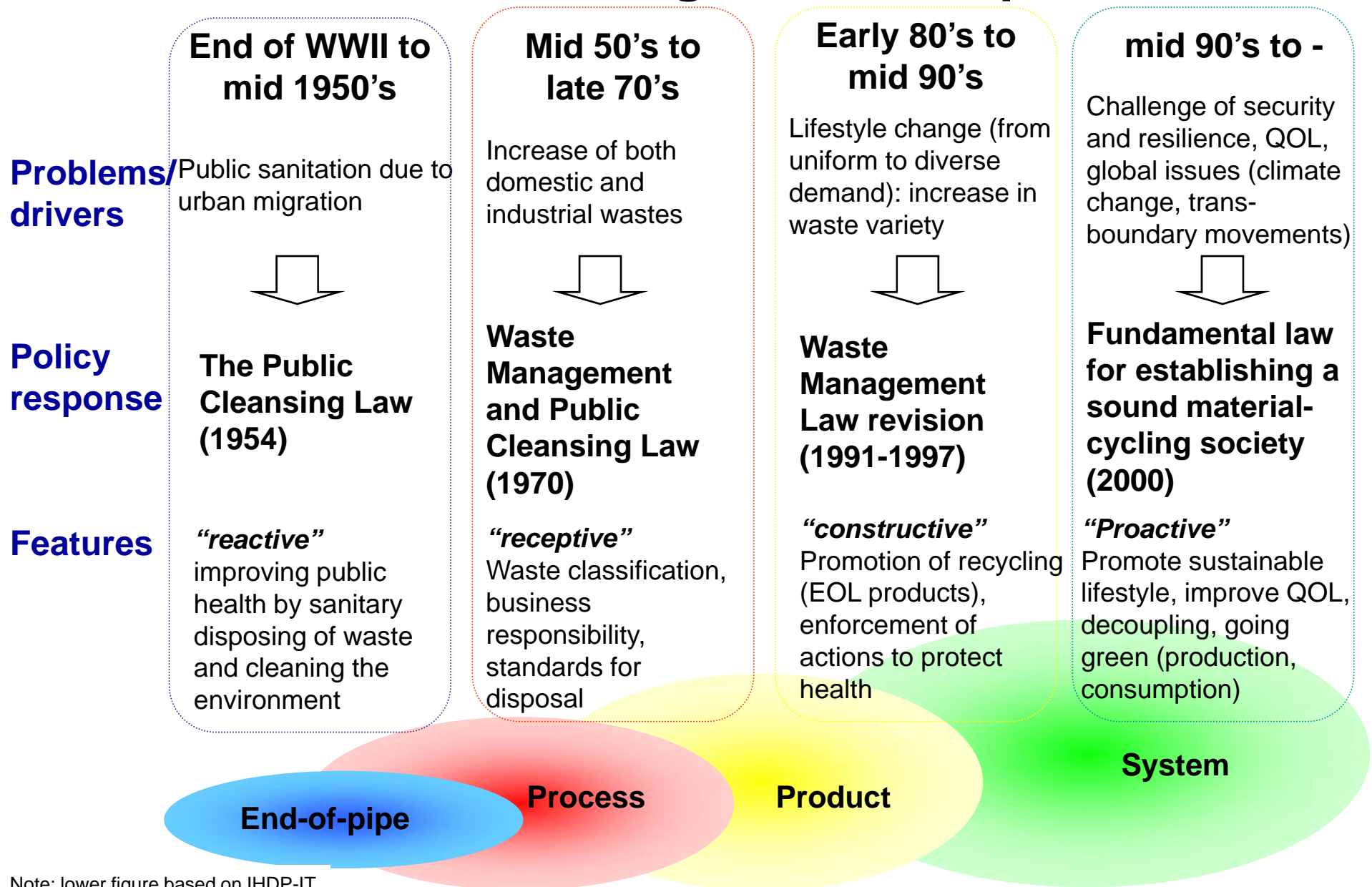


Figure 3. Comparison of MSW Generation Rates and per capita GDP in Asia

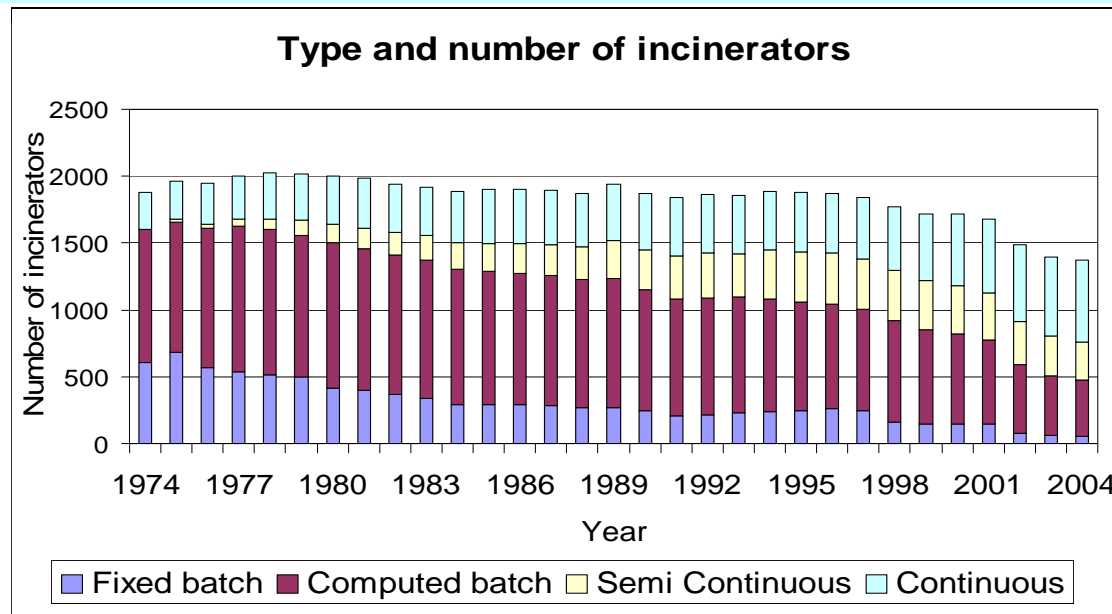
Source: World Bank 1999

# Evolution of Environmental Policies & waste management in Japan

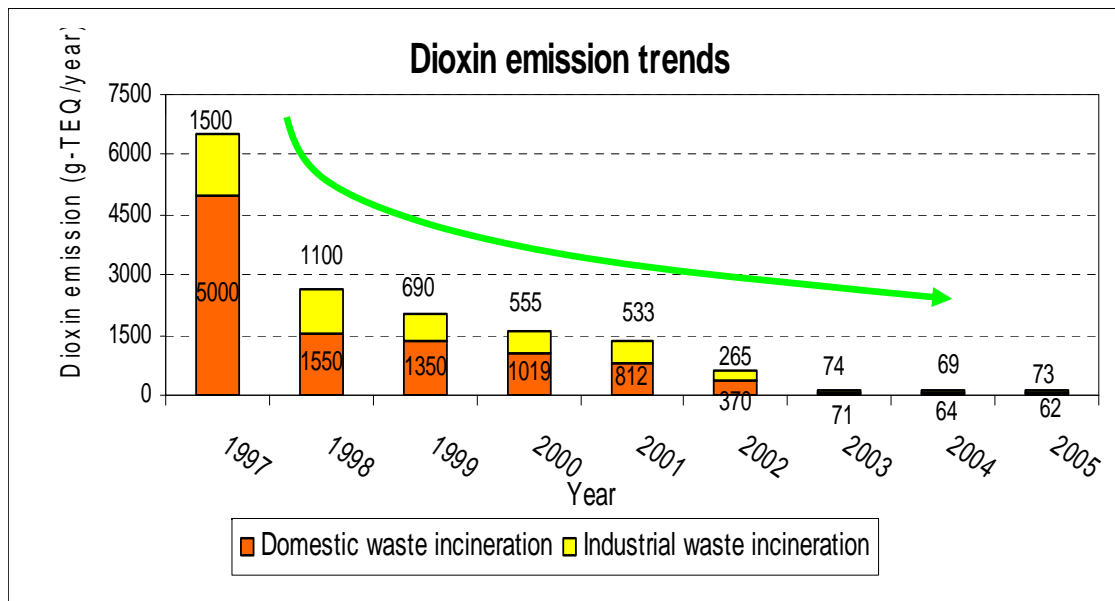


Note: lower figure based on IHDP-IT

# Reliance on Incinerators and Dioxin problems



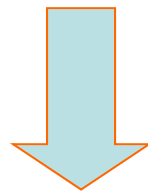
***Types of Incineration facilities had changed.***



***Dioxin emission has reduced drastically.***

# Promotion of Sound Material-cycle Society

- Exploitation of finite natural resources and depletion of the resources
- Growing environmental loads associated with the resource consumptions
- Lack in the final disposal sites (Japan)



***Promotion of Sound Material  
Cycle society became essential.***



# Framework of the Implementation Plan

## *Sound Material-cycle Society (SMS)*

The Basic Environment Law

The Basic Environment Plan

Fundamental Law for Establishing a Sound Material-Cycle Society

Fundamental Plan for Establishing a Sound Material-Cycle Society

*Proper disposal of waste*

*Promotion of recycling*

Waste Disposal and Public Cleansing Law

Law for the Promotion of Effective Utilities  
of Resources

Law for the  
Promotion of  
Sorted  
Collection and  
Recycling  
**Containers and  
Packaging**

*Laws for promoting specific waste recycling*

Law for the  
Recycling of  
Specified Kinds  
of **Home  
Appliances**

**Construction  
Material**  
Recycling Law

Law for  
Promotion of  
Recycling and  
Related  
Activities for  
Treatment of  
Cyclical **Food  
Resources**

Law for the  
Recycling of  
**End-of-Life  
Vehicles**

Local action plan

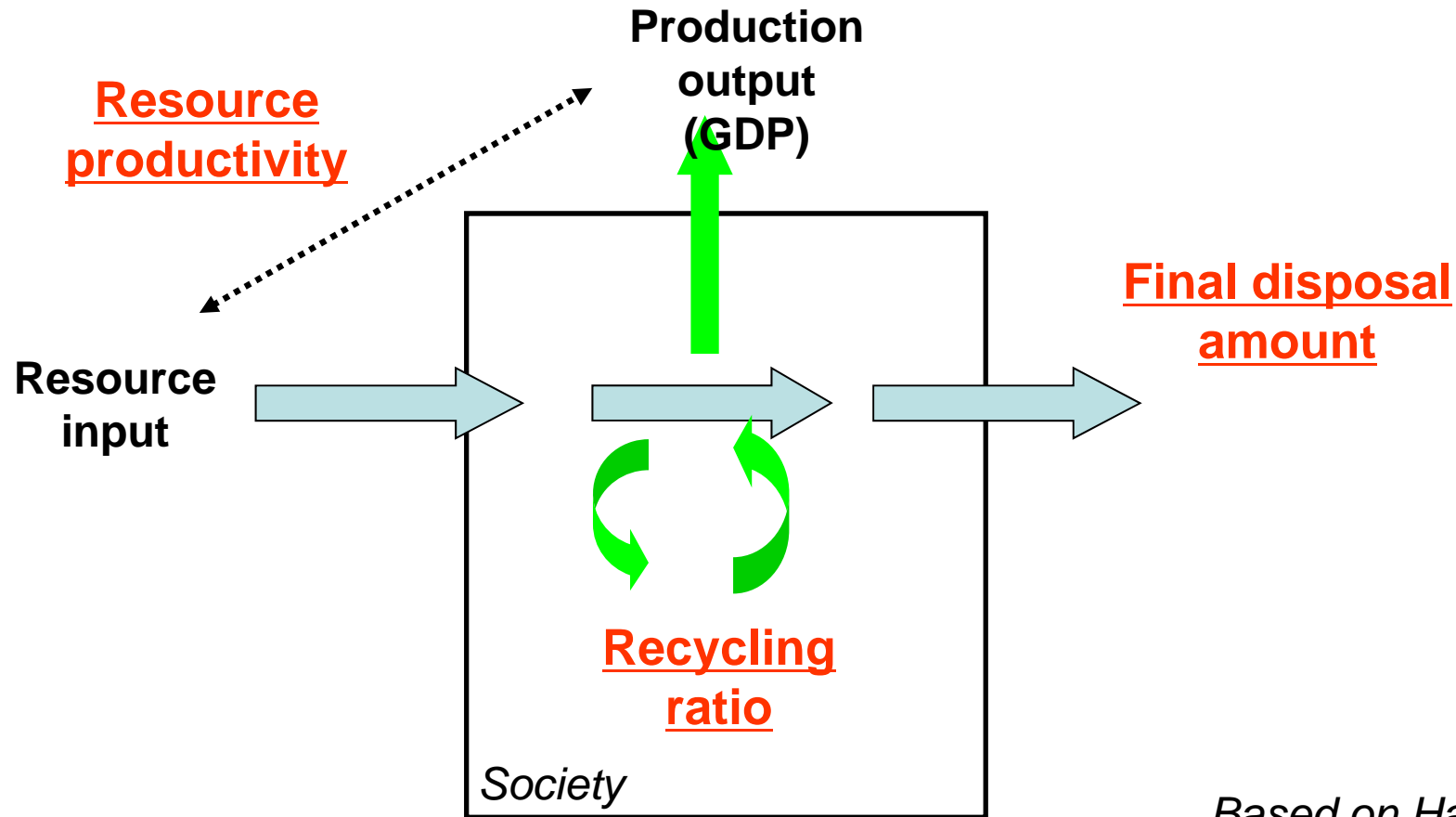
- Plan for Establishing Environmentally Sound Material-Cycle Society in local governments
- Promoting Eco-town Project

Local council

Establishing Council on Promoting Zero-waste City in Tokyo Metropolitan Area and Kyoto-Osaka-Kobe Area



# Three macro indicators

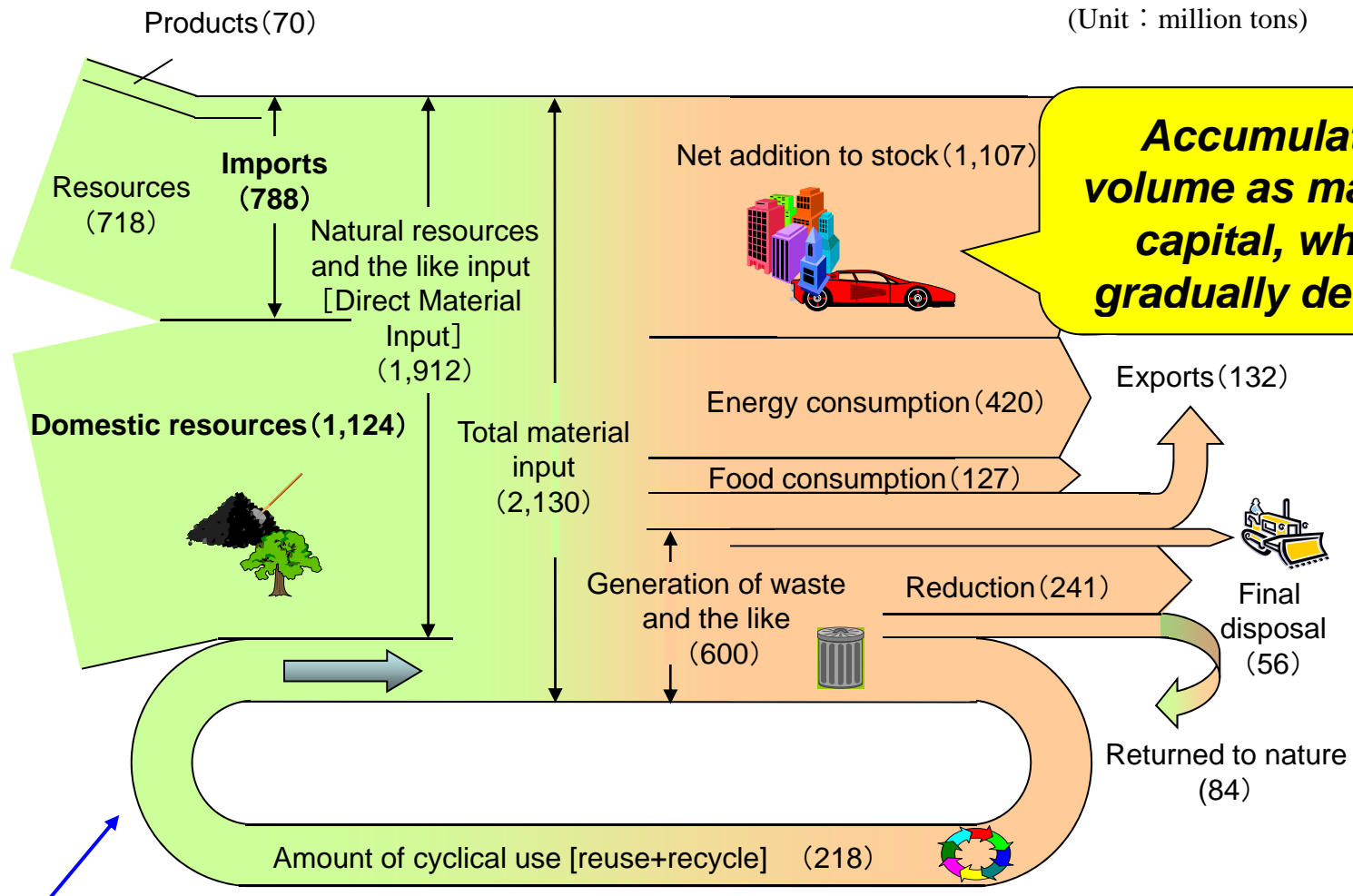


*Based on Hanaki,  
2004*

$$\text{Resource Productivity} = \frac{\text{GDP (Service)}}{\text{DMI}}$$

*DMI: Direct Material Input*

# Analysis of Material Flow in Japan



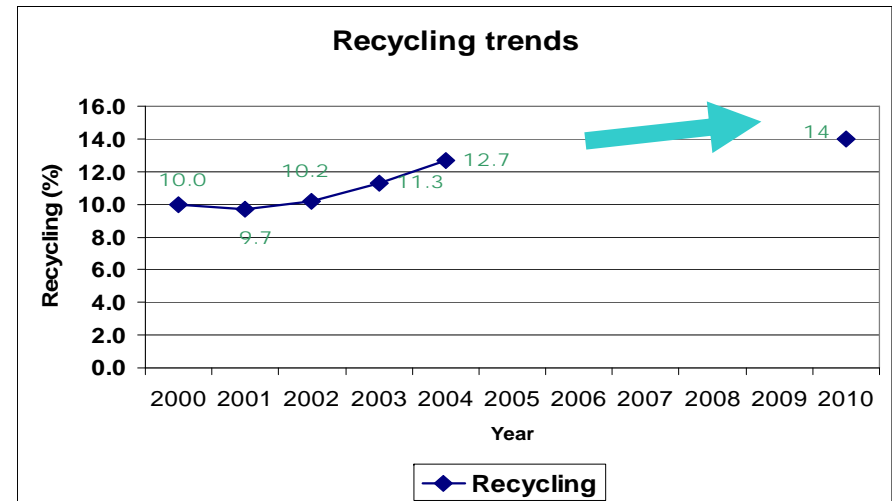
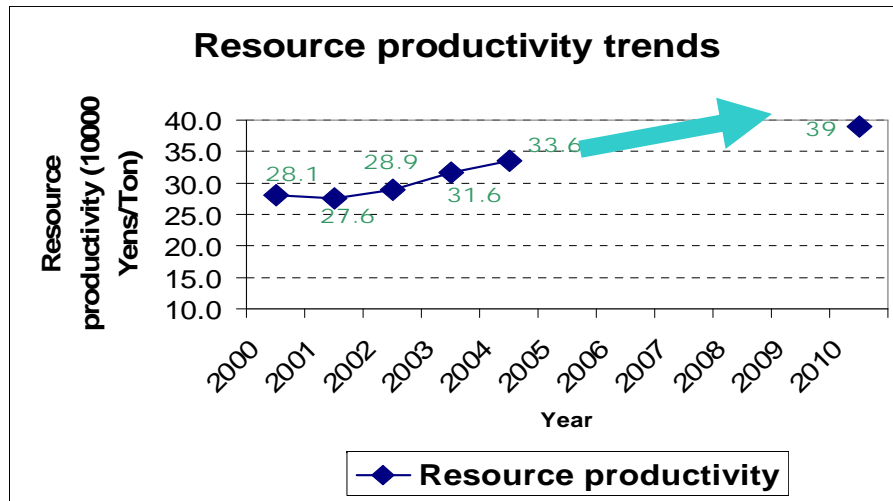
About 10 % of the total material inputs recycled around the year 2000

Ministry of the Environment: Fundamental Plan for Establishing A Sound Material-Cycle Society,  
 <[http://www.env.go.jp/en/rep/waste/plan\\_sound.pdf](http://www.env.go.jp/en/rep/waste/plan_sound.pdf)>

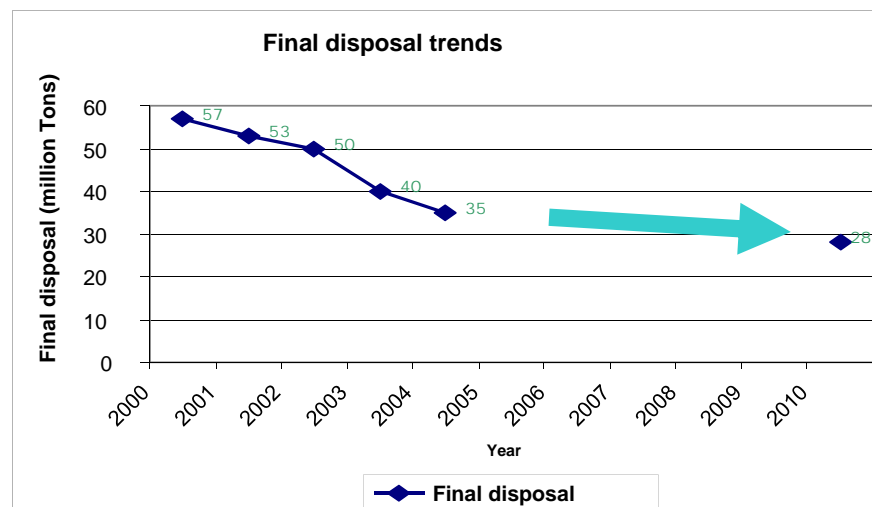
# Macro Indicators to Measure the Material-cycle Society

(A):  $\text{Resource Productivity} = \frac{\text{GDP (Service)}}{\text{DMI}}$

(B): Recycling Rate

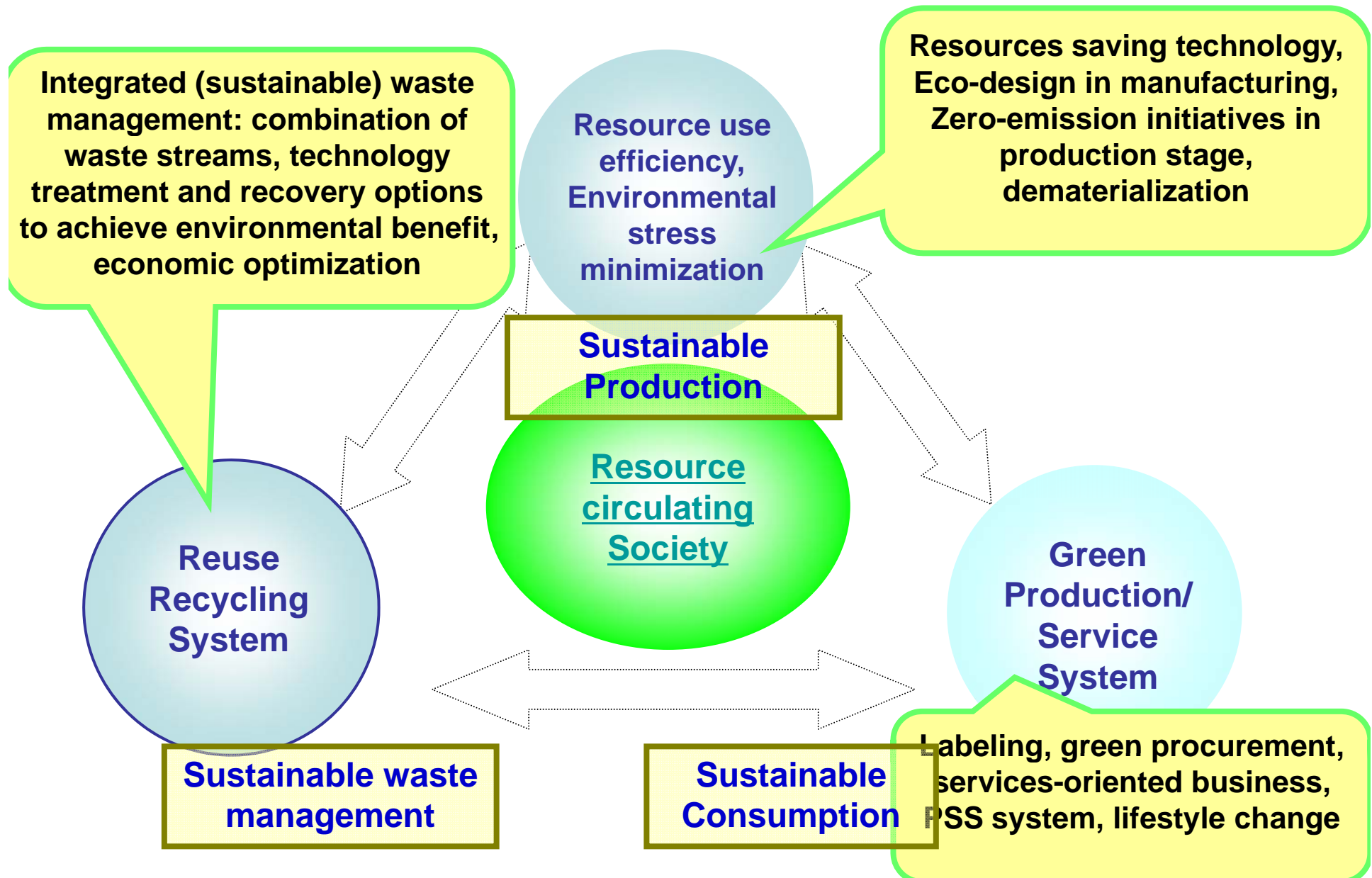


(C): Final Disposal Amount




Fundamental Law for Establishing a Sound Material-Cycle Society was revised in 2008, “**biomass utilization rate**” was included as a monitoring indicator.

# Upstream-Downstream Integration: Downstream Approach



# A summary and discussion – part 1

- Historically, three main characteristics of Japanese wastes managements are observed:
  - 1) Reliance on incineration as a means to reduce waste volume,
  - 2) Material recycling with ambitious recycling targets for specific wastes,
  - 3) An integral resource management approach that stresses not only energy and material recovery but also an increase in resource productivity.
  
- A comprehensive sets of indicator systems with effective monitoring systems shall be further needed to shift the society towards sustainability

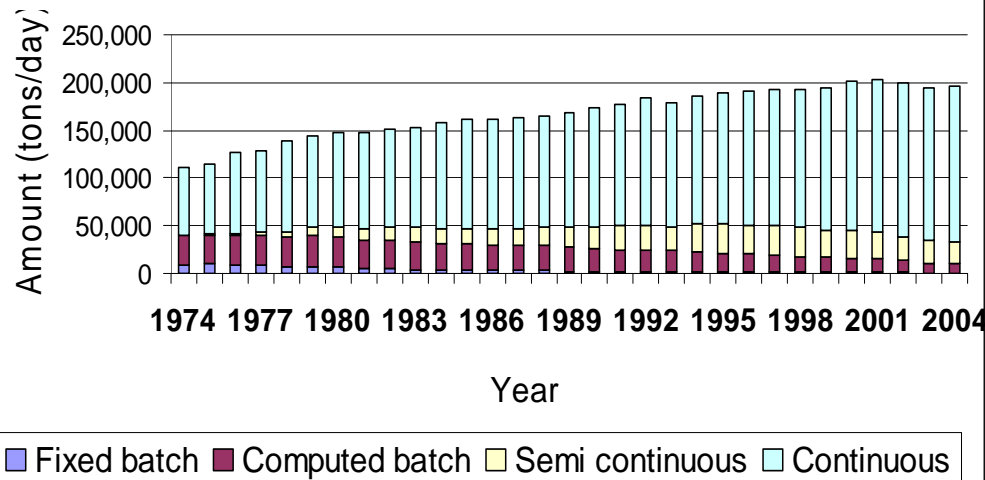


2. Biomass wastes utilization towards a new perspective for waste management and low carbon society – a case of sewage sludge



# Basic guidelines to transform wastes into energy resources

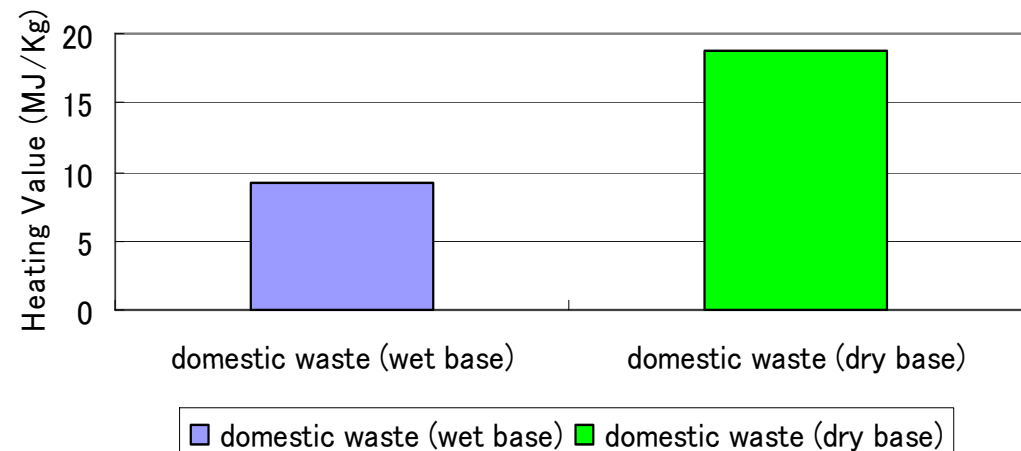
Trends in wastes incineration (by type of incinerator)





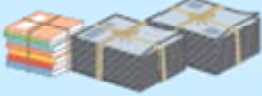






**Until recently, wastes have been primarily incinerated, without fully taking advantage of the recovery potential (energy, industrial use, etc).**

**It is important to change current patterns in waste treatment to obtain the maximum benefits (environmental, economical and social) of wastes**

Heating value for domestic wastes (MJ/Kg)



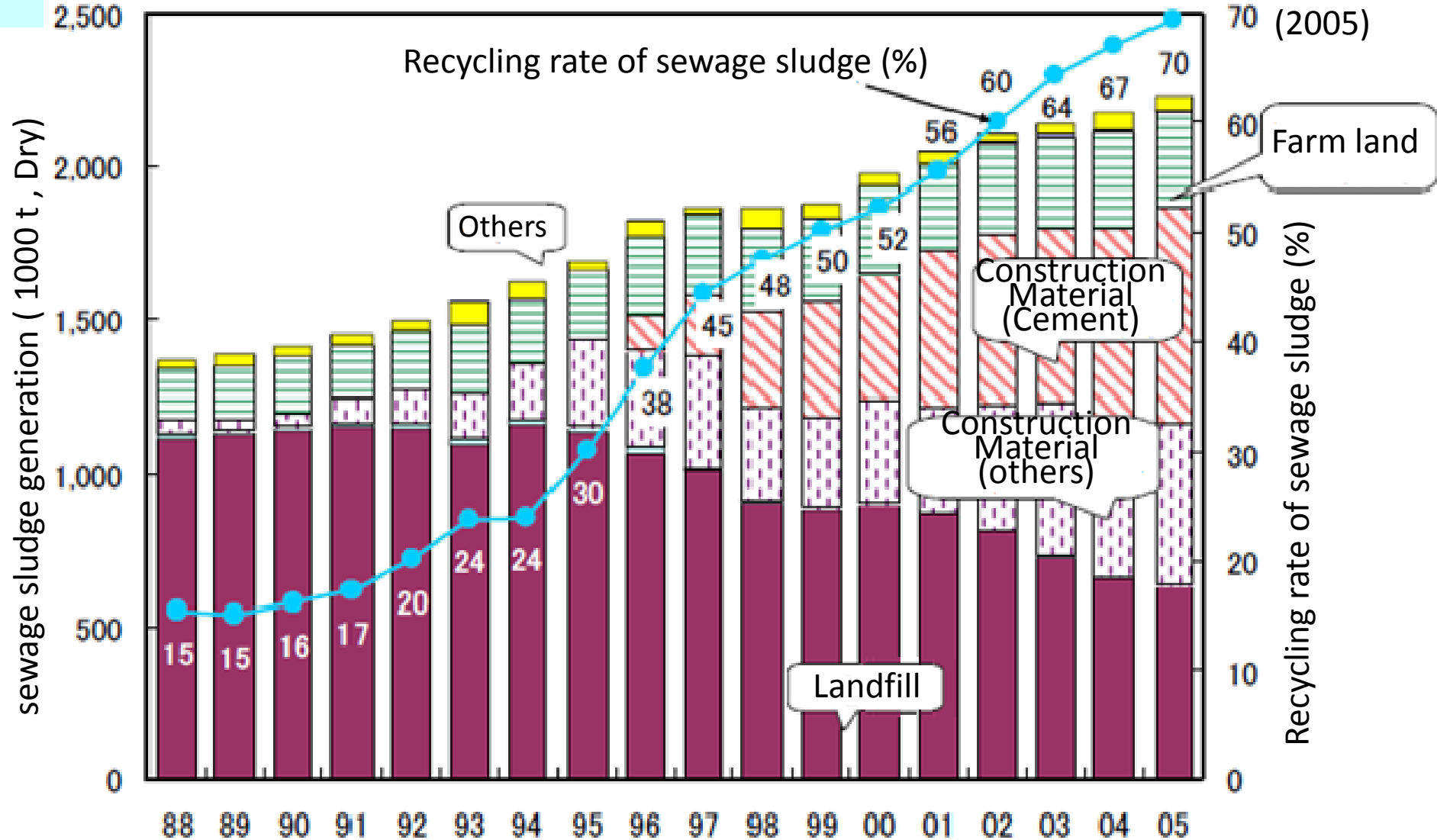
# Generation and Utilization of biomass in Japan, 2005

biomass	annual output	state of utilization
animal manure 家畜排せつ物 	x 10 <sup>4</sup> ton 約8,900万トン	use 約90% non-use 約10%
food waste 食品廃棄物 	約2,200万トン	未利用 80%
waste paper 廃棄紙 	約1,400万トン	
Black liquor ハルブ廃液 (乾燥重量) 	約1,400万トン	
sawmill residuals 製材工場等残材 	約 500万トン	use 約90% non-use 約10%
wooden construction waste 建設発生木材 	約 460万トン	use 約60%
forestland residuals 林地残材 	約 370万トン	
sewage sludge 下水汚泥 (濃縮汚泥ベース) 	約7,500万トン	use 約64% non-use 約36%
non-eatable organics 農作物非食用部 (稲わら、もみがら等) 	約1,200万トン	use 約30% non-use 約70%

Source: MAFF

# Utilization of sewage sludge

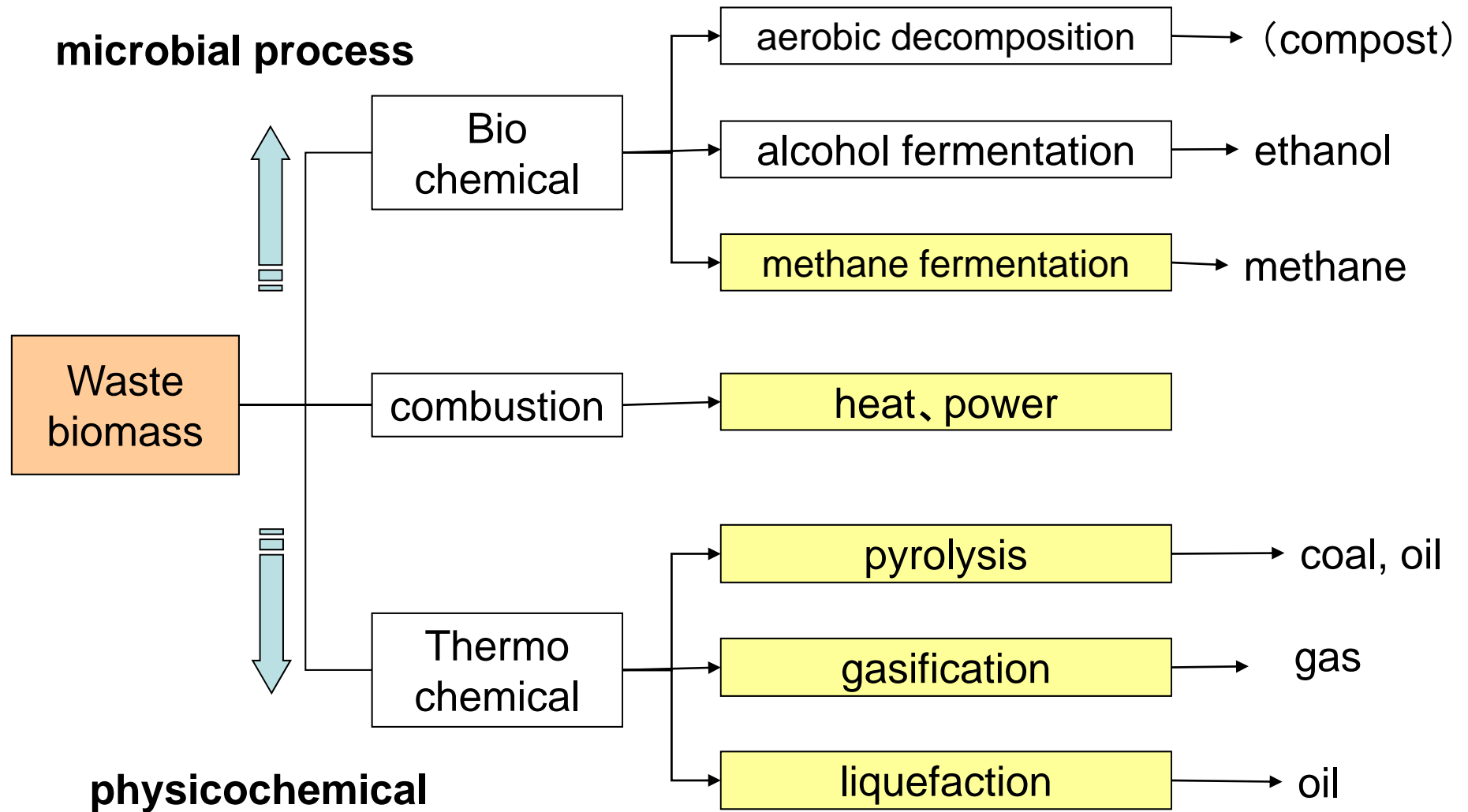
2,227,000  
DStons  
(2005)



**Utilization of sewage sludge as energy resources covers only 7% of total.**

Source: Ministry of Land, Infrastructure and Transport

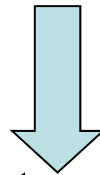
# Energy conversion technologies of biomass



**yellow-colored technologies are related to sewage sludge.**

# Backgrounds of sewage sludge management in Tokyo

- The volume of raw sewage sludge has been **Increasing** steadily.
- Tokyo has historically suffered from **limited capacity** of **final disposal site**.
- **No agricultural use, composting use**

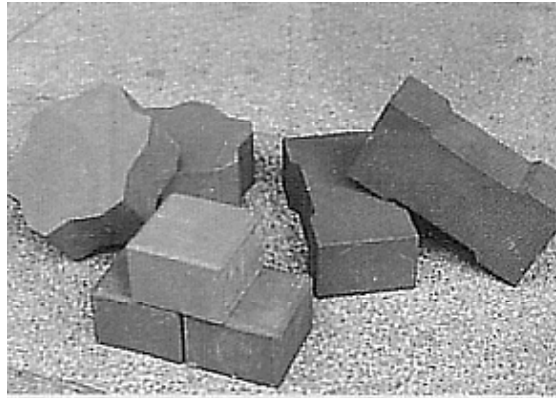


Sewage management system has been designed to reduce the sludge volume eventually disposed in final disposal sites

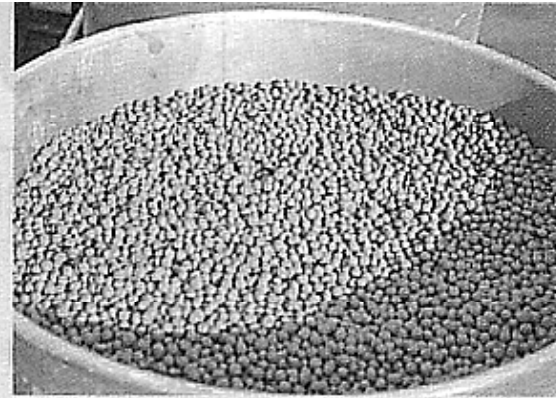
## For reducing the amount of final disposal

- **Incineration** has been facilitated.
- **Sludge recycling** (Brick, Aggregate, Slag, RDF) has been tested.
- **Utilization of ash in cement industry as raw material for cement** (since 1998)

# Sludge recycling products at *Nanbu* plant



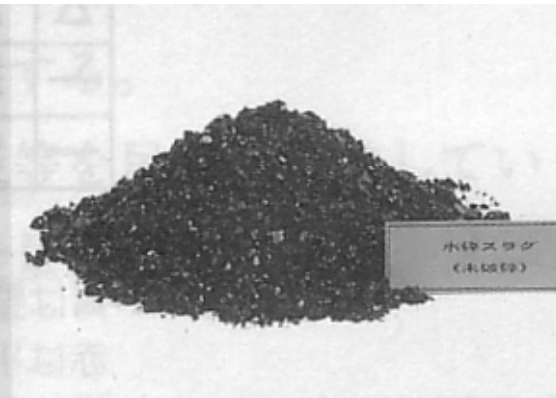
Brick



Aggregate



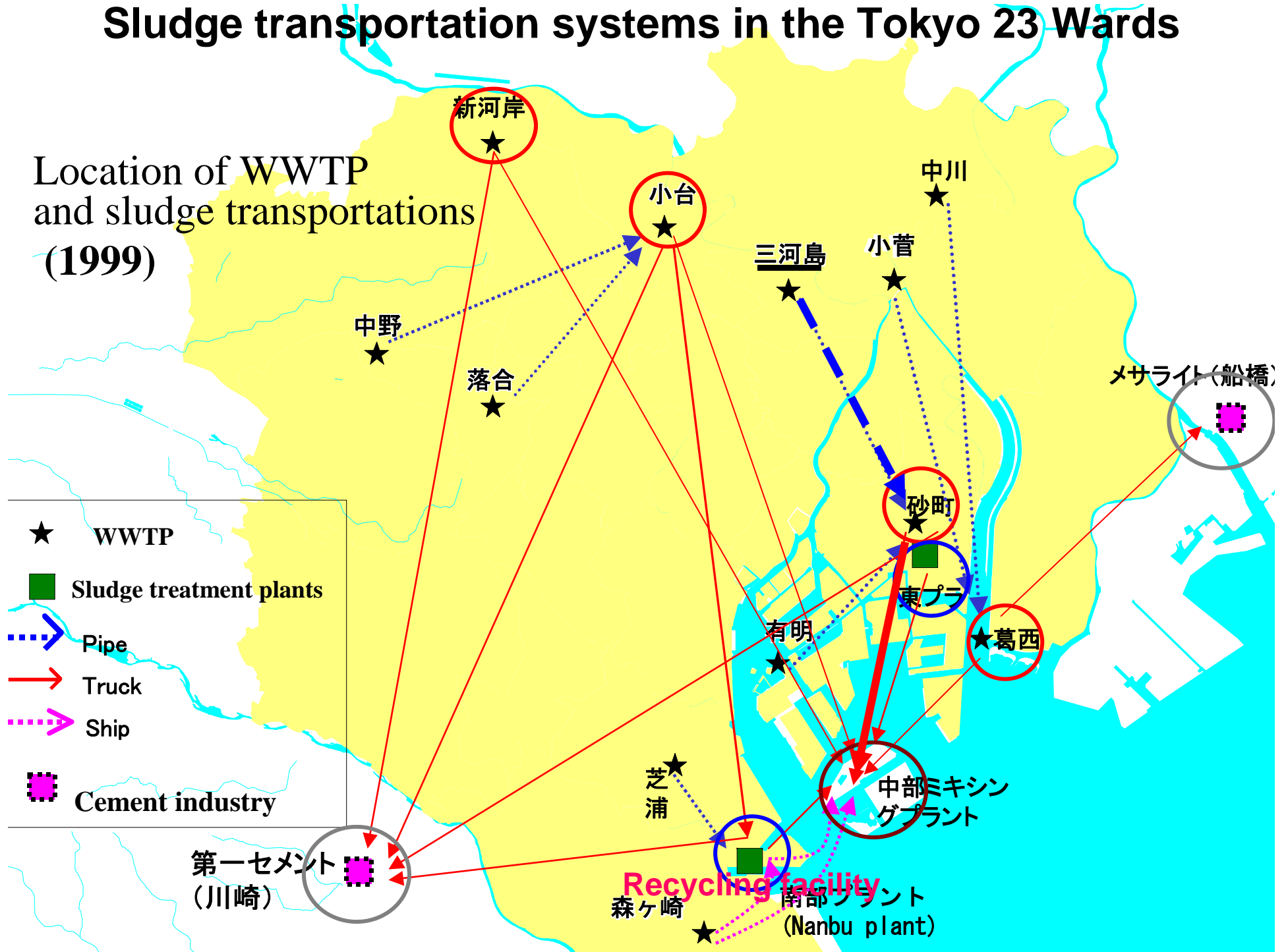
Refuse Derived Fuel (RDF)



Slag

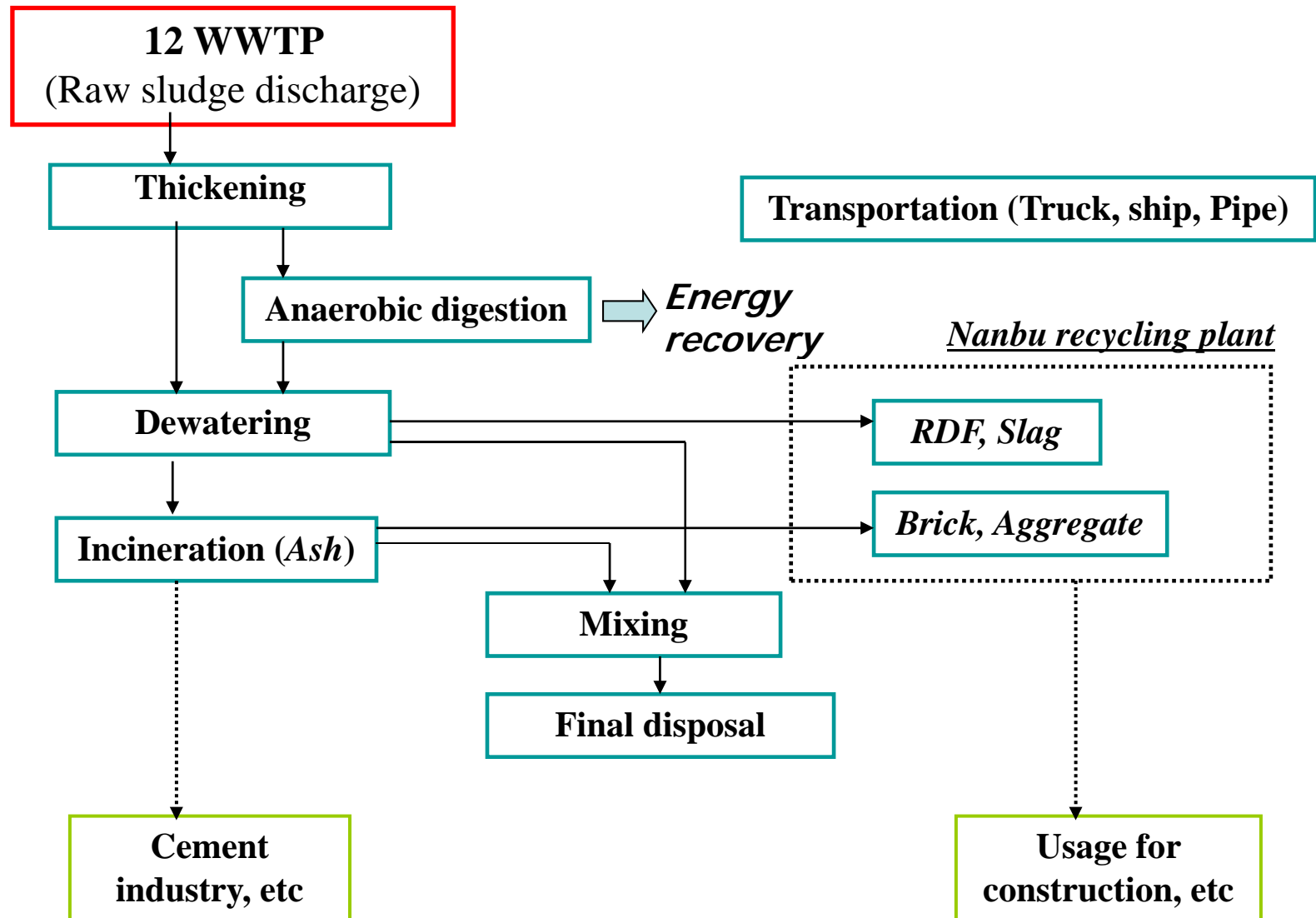
# Sludge transportation systems in the Tokyo 23 Wards

Location of WWTP and sludge transportations (1999)

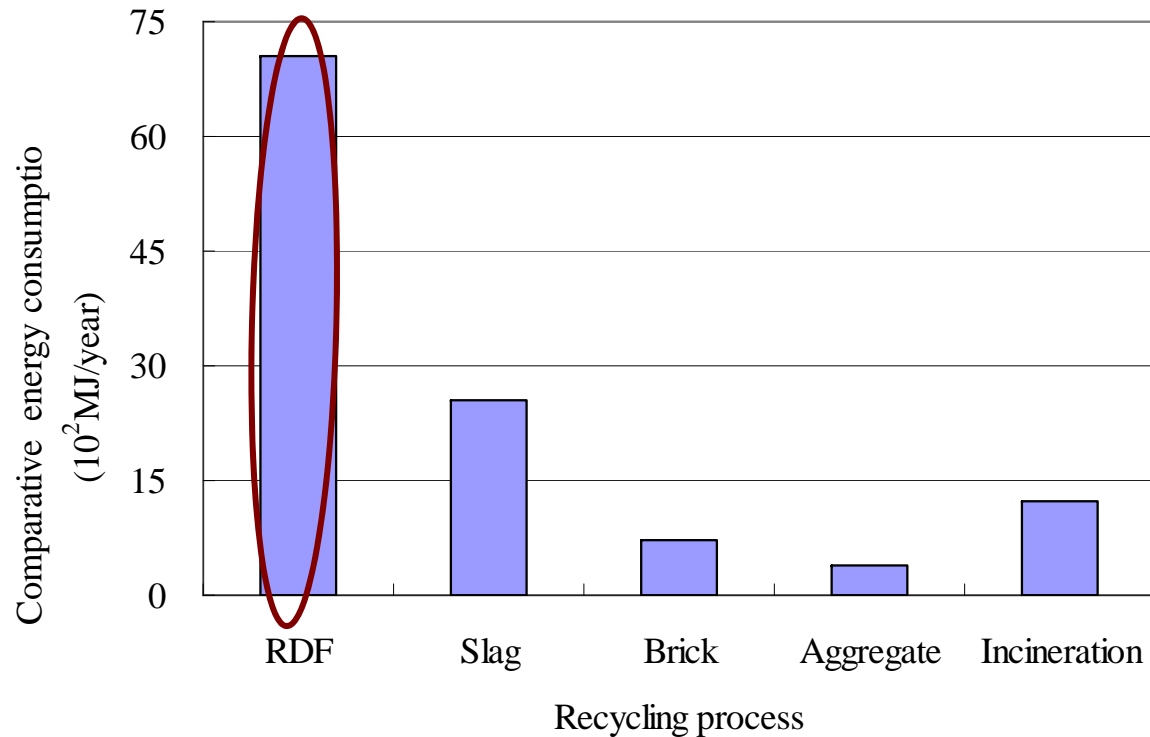




# Summarized sludge management system in the Tokyo 23 Wards area



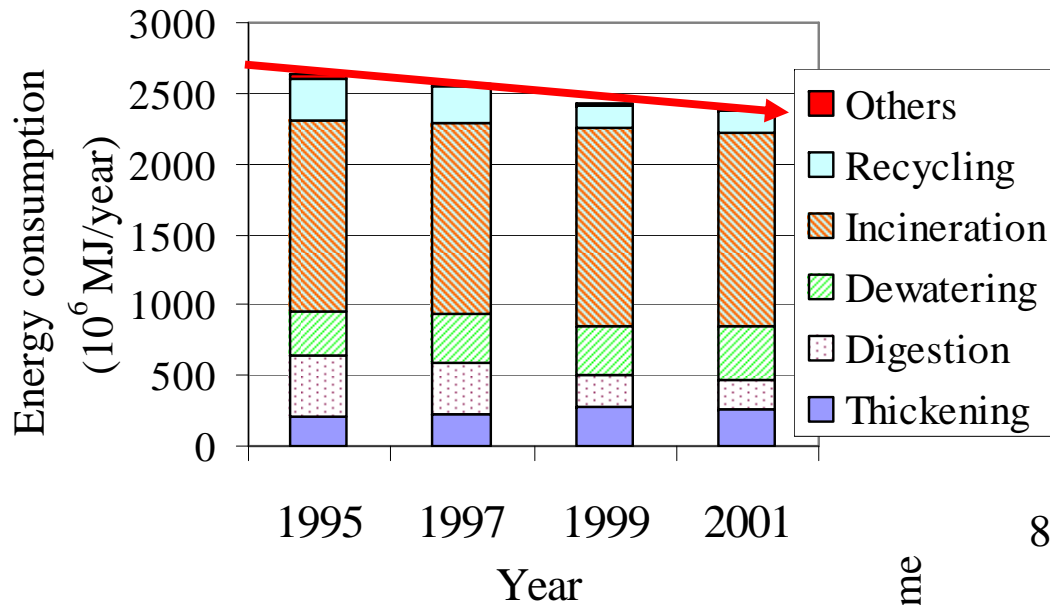
# Comparative energy consumption in each recycling process



Source: Hara, K and Mino, T. (2008). Environmental Assessment of Sewage Sludge Recycling Options and Treatment Processes in Tokyo, Waste Management, Vol 28 (12), pp. 2645-2652



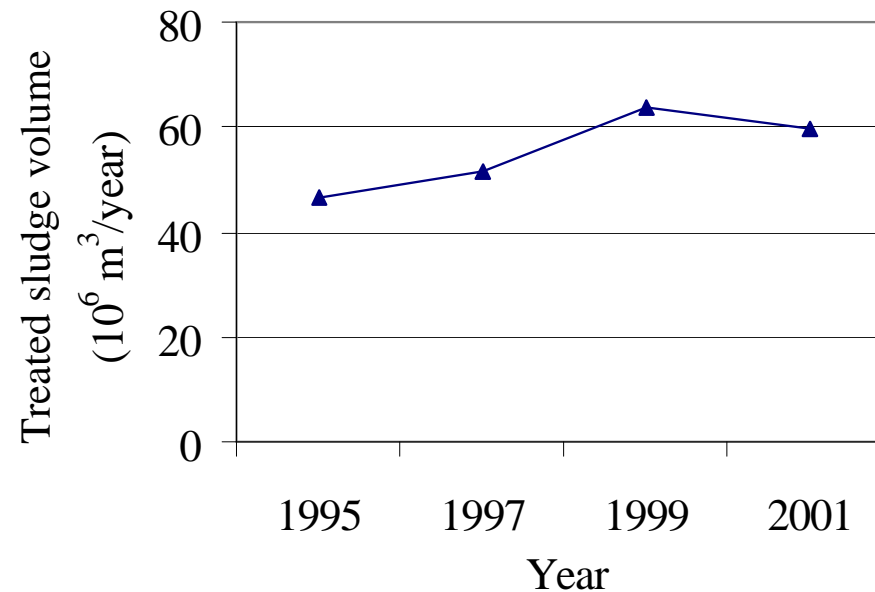
# Energy consumption



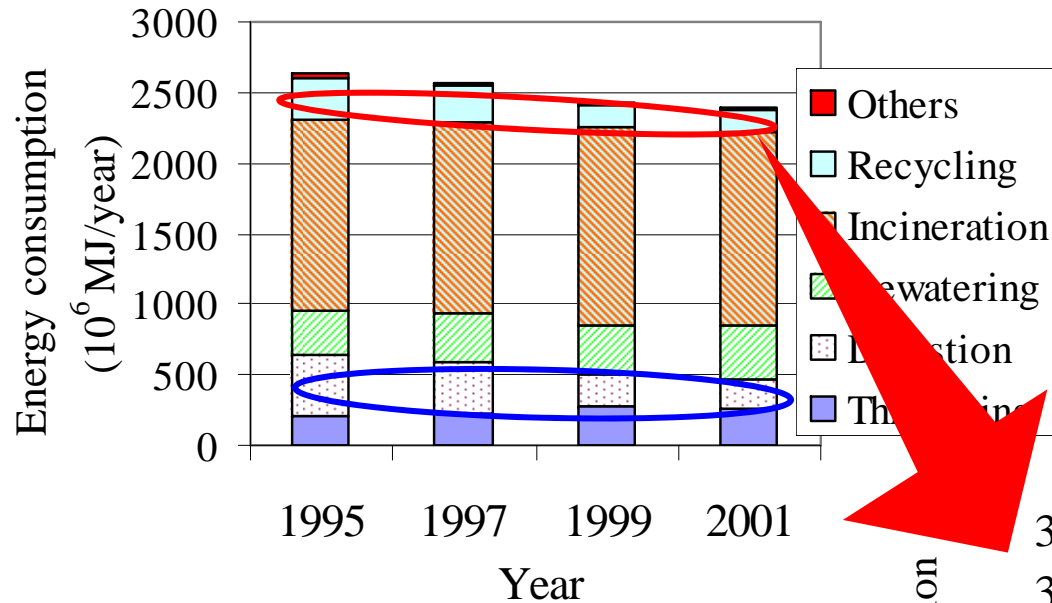
**Total energy consumption shows a tendency to decrease.**

Note: "Others" is the sum of mixing, transportation and final disposal process.

**Raw sludge volume has been increasing.**

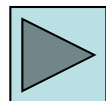
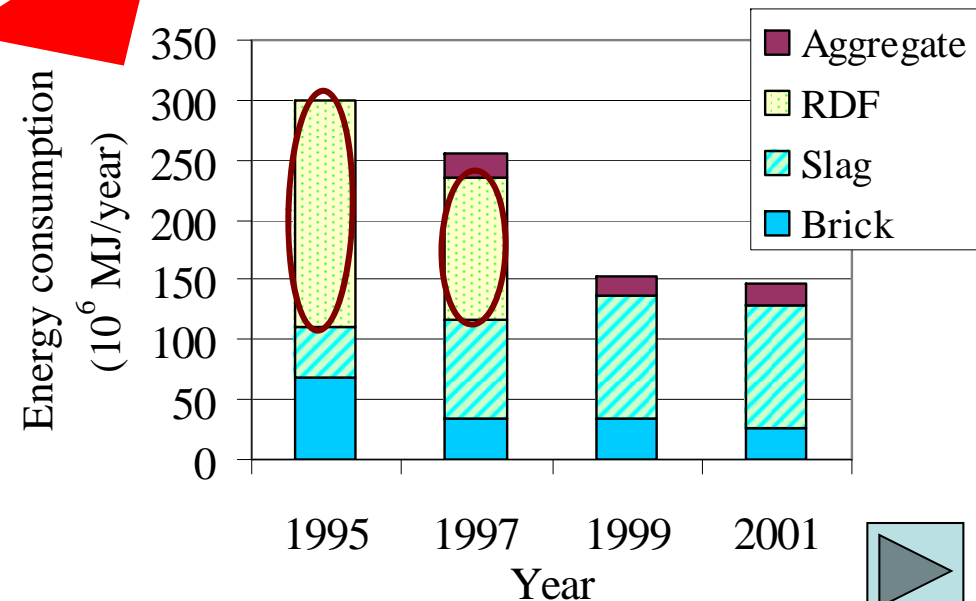


# Energy consumption in recycling process

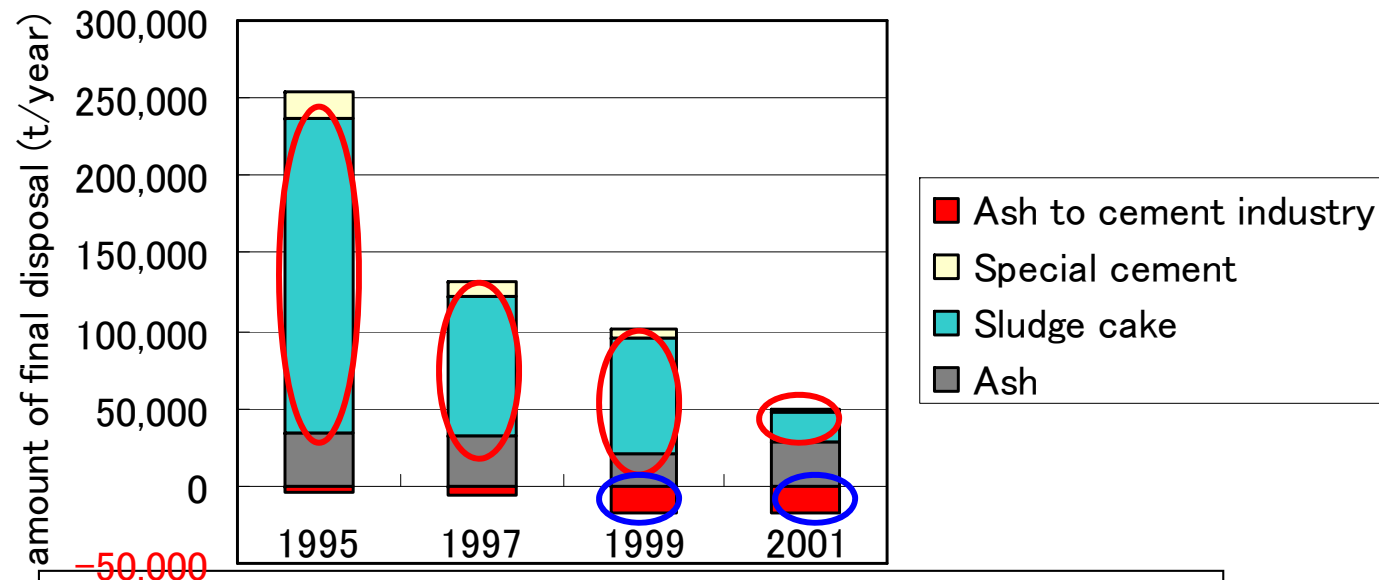


***This reduction can be mainly explained by reduction in recycling and digestion process.***

***RDF process which constituted the largest part in 1995 and 1997, was scrapped after 1997.***



# Amount of final disposal



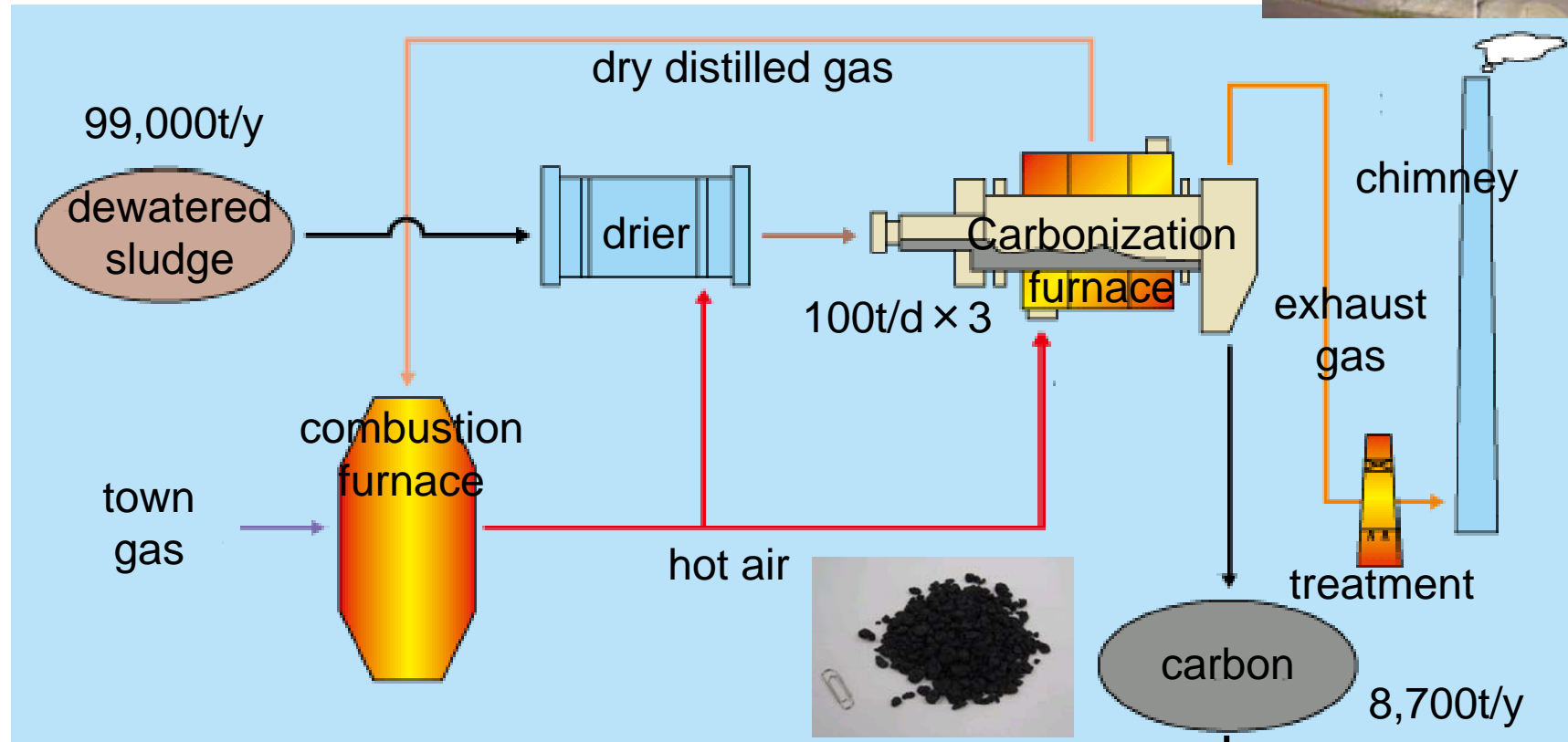
***Due to the increase of incineration ratio, the amount of final disposal decreased significantly.***

***Utilization of ash in cement industry was started in 1998.***

## **New perspective in sewage sludge management in Tokyo (Japan)**

- Shift to more energy efficient material use, such as cement production.
- **Re-evaluation of sewage as an energy source (i.e. methane production), in the era of global warming.**
- Integrated management with other wastes such as household wastes

# Carbonization in *Tobu* sewage plant

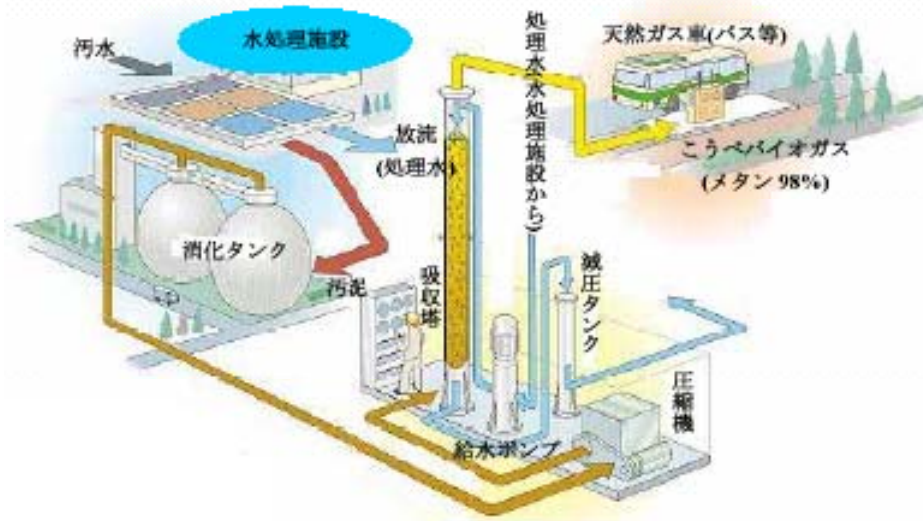


**Carbonized sludge is used as a substitute of coal for power generation.**

coal-fired power station



# Methane fermentation In *Kobe* sewage plant



Flow of bio gas utilization



Digestion tank

An advanced purification technology increases the concentration of methane up to 98% and use this purified gas for running city buses.



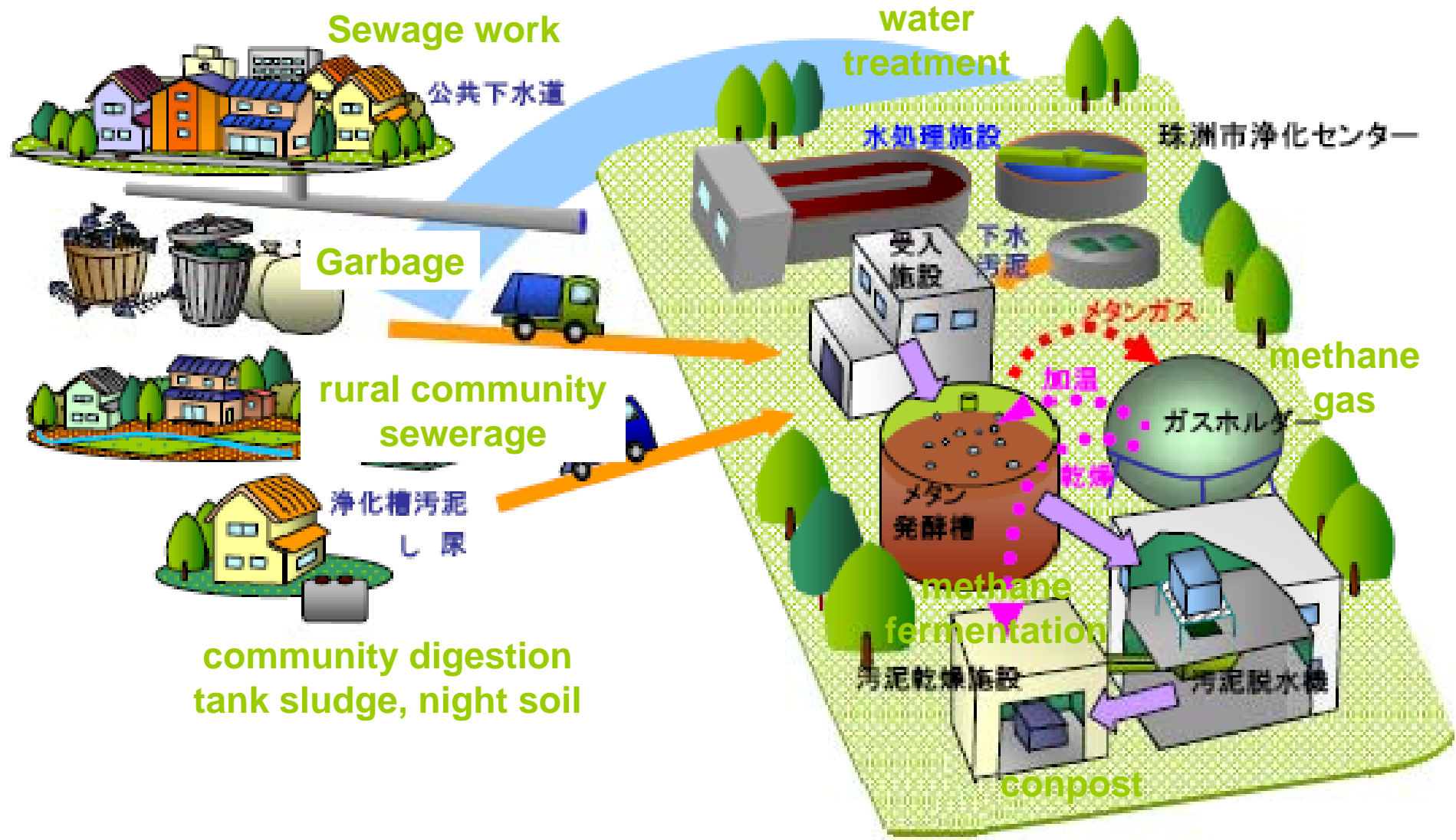
Purification of methane gas



City bus running with methane gas



# Pioneering case of integrating various environmental facilities to co-utilize local biomass resources –Kuzu City, Ishikawa -

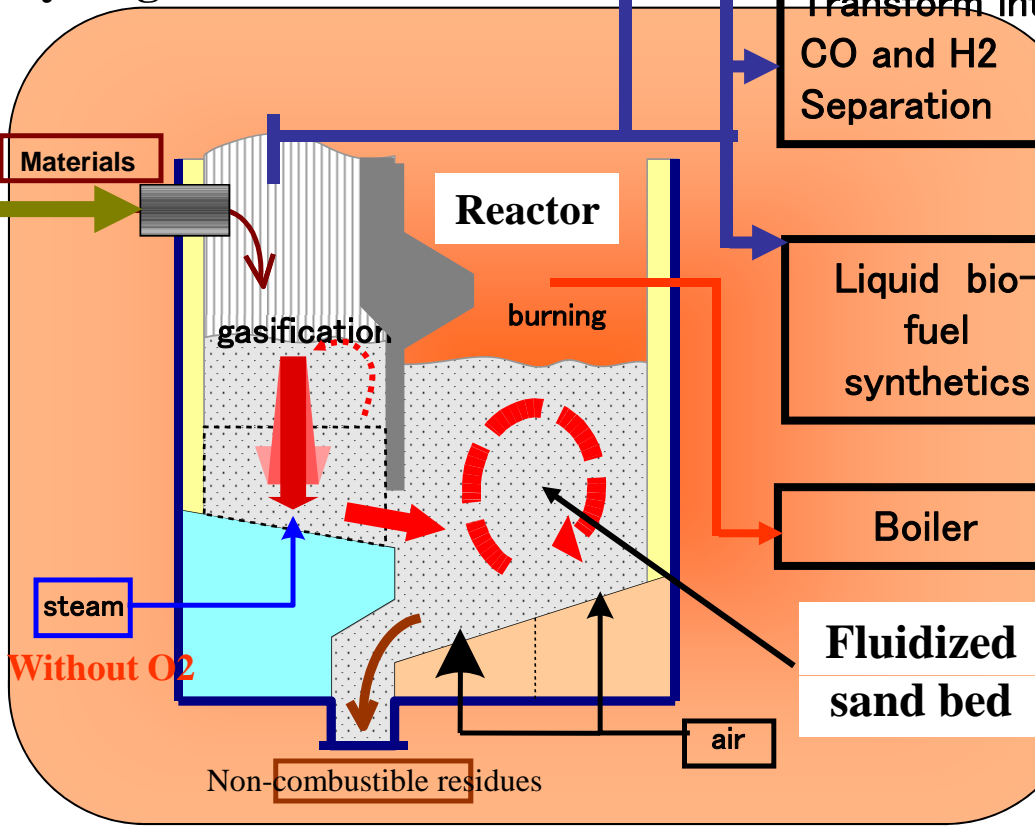


# Innovative transformation of biomass for renewable energy/chemical multiple production

Bio-oil equivalent to heavy oil

Various uses from products in biomass gasification

Yield Gas in high temperature: Hydrogen and Carbon-oxide



Impurity removal

Transform into CO and H<sub>2</sub> Separation

Liquid bio-fuel synthetics

Boiler

Clean gas

Gas turbine

Gas engine

Hydrogen

Methanol

Di-methyl Ether

Steam



## A summary and discussion – part 2

- Utilization of biomass in urban and rural areas is an essential policy direction to develop a sustainable society (with sound-materials cycle society and low-carbon society, combined.)
- Institutional designs for integrated approaches are indispensable in promoting biomass utilization.